Lean Six Sigma and Environment Case Study: JEA

Summary

JEA is an electric, water, and sewer utility located in Jacksonville, Florida and parts of three adjacent counties. The JEA water system serves more than 305,000 water customers and 230,000 sewer customers in Northeast Florida. JEA's water is supplied from 134 artesian wells, which tap the Floridan aquifer, and water is distributed through 26 water treatment plants and 4,208 miles of water lines. JEA collects sewage through more than 3,760 miles of collection lines, and uses seven regional and eight non-regional sewer treatment plants to complete sewage treatment for its customers. Essentially all the sludge from all treatment facilities is consolidated at the Buckman Street facility for production of Green Edge fertilizer, which is sold through the Ace Hardware chain. The JEA electric system currently serves more than 417,000 electric customers in Jacksonville. The utility has applied Lean and Six Sigma process improvement techniques since 2000.

Process improvement efforts at JEA have produced the following overall results:

- Achieved a utility-wide cumulative cost savings of $579 million from Lean and Six Sigma initiatives.
- Avoided an impact of $95 million on the utility's 2010 budget from projects specifically focused on cost reduction.
- Saved an average of $950 per customer and avoided rate increases of $20 per month directly related to process improvement efforts.
- Completed over 580 projects since 2000.

Results from the St. Johns River Nitrogen Discharge Reduction Project:

- Reduced nitrogen discharge to the St. Johns River by 74 tons per year.
- Met new federal standards for nitrogen discharge limits in fiscal year 2010 that go into effect in 2013, without investing in additional treatment technology and with reduced operational costs.
- Developed a process to recycle a byproduct from biodiesel fuel production (a hazardous waste) for a beneficial use and reduced the volume of materials that enter landfills every year.
- Provided a potential $2.37 million per year benefit to the utility from nitrogen credits (assuming a value of sixteen dollars per pound of nitrogen).
- Increased cooperation between JEA and local municipalities.
- Improved public perception of JEA and positively affected customer relations by recycling hazardous waste and reducing nitrogen discharge.

Results from the Water Maintenance Truck Safety and Efficiency Project:

- Increased the number of jobs per day that each water maintenance crew is able to complete from 4.36 to 6.23, which is a total of 479 additional jobs per year across the fleet of trucks.
- Increased the efficiency of ticket completion—the project reduced average time to complete all types of tickets for water maintenance crews from 78 minutes to 55 minutes, a 30 percent reduction.
- Improved the safety of the work environment for employees. As of October 2010, there have been zero Occupational Safety and Health Administration (OSHA) recordable safety violations and zero vehicle accidents since improvements were implemented in 2006.
- Reduced fuel costs by an estimated 10 percent per truck.
- Improved customer satisfaction as a result of jobs being completed in less time.

Results from Sanitary Sewer Overflow (SSO) Reduction Projects:

- Reduced SSOs from 43 per month in 2002 to 30 total from October 2009 through September 2010 (average of 2.5 per month over 12 months) using data-driven Lean Six Sigma methods.

Lean and Six Sigma Implementation at JEA

JEA selected Six Sigma as an improvement methodology in 1999, began training "Black Belts" in 2000, and conducted its first Six Sigma projects in 2001. JEA incorporated Lean methods into its Six Sigma methodology over time and formally integrated the Lean and Six Sigma approaches in 2007. As of summer 2010, JEA had eight full-time Black Belts supporting Lean and Six Sigma projects at the utility, as well as 24 Black Belt-trained directors and vice presidents, including the head of water planning. JEA has completed over 580 improvement projects. Of those projects, project leaders selected 329 because of the positive financial impact that those projects had in terms of money saved for the utility. Today, JEA's trained Lean and Six Sigma team provides benchmarking services worldwide in addition to supporting process improvement at JEA.

Since project implementation began at JEA, the utility has accumulated millions of dollars in annual savings as a result of Lean and Six Sigma process improvement efforts. Over the nine years in which Lean and Six Sigma projects have been saving money for the utility, the cumulative cost impact has been $579 million, which is an average of $950 savings per customer. From 2001 to 2010, process improvement projects have enabled the utility to avoid about $20 per month per customer in rate increases. JEA's 2010 budget avoided an impact of $95 million as a result of Lean Six Sigma cost reduction projects.

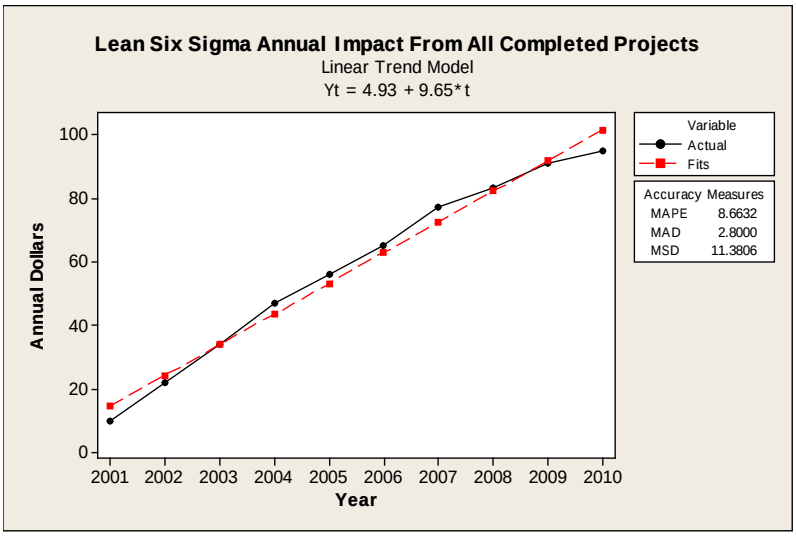

Figure 1: Annual Savings at JEA Due to Lean and Six Sigma Projects

JEA's process improvement approach draws from both Lean and Six Sigma methodologies. The backbone for JEA's process improvement efforts is a modified version of the Six Sigma DMAIC process. DMAIC encompasses the five steps of Define, Measure, Analyze, Improve, and Control. Through these steps, JEA defines specific goals, collects measurements to gain an understanding of the current problems, analyzes causes, effects, and conflicts in the present system, identifies possible improvements, and selects those with the greatest positive effect, and controls to ensure that any

outstanding variances are corrected before they can cause lasting effects. In 2008, JEA added a "Green It Up" step to the DMAIC process, creating "DMAGIC;" this step is designed to ensure that every improvement project addresses environmental concerns. As a utility, JEA places a high priority on including environmental metrics, thereby ensuring that the utility maintains a socially responsible role in the community it serves.

JEA's "DMAGIC" Analysis

Define
Measure
Analyze
Green It Up
Improve
Control

In the "Green" phase of each project, the team explores areas such as air quality, water quality, and ecosystem-related issues. The team performs the "Green it Up" phase after identifying root causes and before developing any countermeasures. This assures that environmental and societal concerns are "baked into" every countermeasure explored before it is evaluated. The Environmental Relationship Matrix, shown below, is used to identify the root causes of environmental issues identified. The matrix assures that, at a minimum, the enumerated areas are considered.

Project X's → *Root Causes*		Outcome 2	Outcome 3	Outcome 4	Outcome 5
Air Quality Issues					
1	Climate Change				
2	Air Emissions				
3	Odor Impacts				
Water Quality Issues					
4	Groundwater and Aquifer Quality				
5	Surface Water Quality incl. St. Johns River				
6	WWTP/WRF Discharge				
7	Sanitary Sewer Overflows				
8	Reclaimed Water				
Waste Stream Issues					
9	Solid Waste By-Products				
10	Hazardous Waste Management				
11	Chemical or Oil Spills				
12	Waste Reduction and/or Recycling				
General Ecosystem Issues					
13	Wetlands Impacts				
14	Tree and Vegetation Impacts				
15	Wildlife Impacts				
Societal and Economic Issues					
16	Environmental Stakeholder Relationships				
17	Environmental Regulatory Agency Interface				
18	Power Reliability/Quality				
19	Drinking Water Quality				
20	Energy Conservation				
21	Water Conservation				

Table 1: Environmental Relationship Matrix

Example Projects

The remainder of this case study highlights three examples of Lean and Six Sigma projects at JEA—a project to reduce nitrogen discharges into the St. Johns River, a project to improve truck safety and reduce the time to complete water maintenance jobs, and process improvements to reduce SSOs.

St. Johns River Nitrogen Discharge Reduction Project

Problem: Nitrogen Discharge Fluctuation

Through an innovative Lean Six Sigma project, JEA identified and implemented changes to its water processing system that dramatically reduced nutrient discharges to the St. Johns River. JEA operates under a self-imposed commitment to meet or exceed EPA mandates prior to the year when the standards will take effect. In 2008, utility managers set a goal of meeting the 2013 EPA standard for nitrogen discharge to the St. Johns River by 2010 and initiated a Lean Six Sigma Project to help to achieve that goal.

In the "Define" phase of the project, after studying 67 weeks of data, JEA observed that nitrogen discharge was always at its lowest level on Friday evening and rose each weekend to reach a peak level on Monday morning, and then subsequently declined throughout the week. This pattern negatively affected monthly nitrogen totals reported to the Florida Department of Environmental Protection.

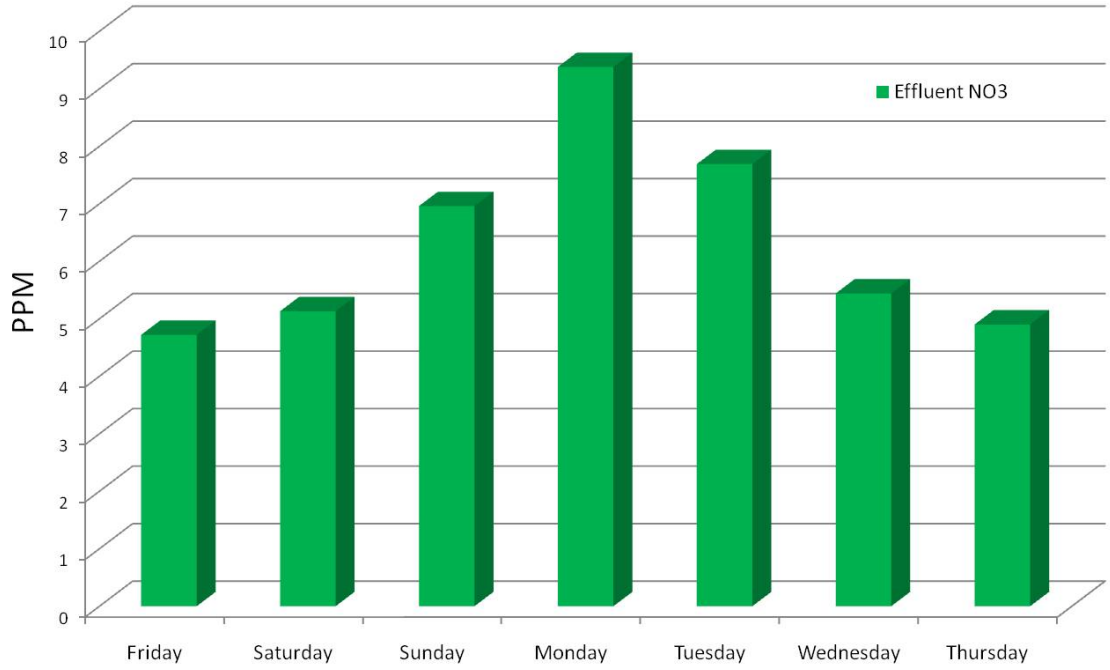

Figure 2. NO_3 Discharge by Day of the Week at Buckman Street Wastewater Treatment Plant

Determining Process Changes through DMAGIC Analysis

Through the DMAGIC process, the project team set out to identify and analyze the root causes of the high nitrogen discharge levels on Mondays, and then brainstorm, test, and implement process changes

to address those root causes and reduce the peak nitrogen loads without negatively affecting plant operations. The team considered the following possible causes of the trend in nitrogen discharge levels:

- Air flow
- Primary effluent biological oxygen demand (BOD)
- Dissolved oxygen
- Food to microorganism (F/M) ratio
- Water temperature

Operations staff manually tested 24 composite samples daily for influent NH_3 and effluent NO_3 and recorded the results. The process improvement team performed a multivariate regression analysis to determine the relevance of the potential causes of the variation in nitrogen discharge throughout the week. The analysis led to the conclusion that the nearby fish processing facility's weekend cessation of operations was causing the water treatment plant's sewage-treating microbes to die off between Friday evening and Monday morning each week. When the fish processing facility halted its effluent of fish by-products each weekend, the microbes would die, and nitrogen levels would spike every weekend.

JEA was faced with the challenge of keeping the sewage-treating microbes alive and thriving during the course of each weekend. The project team developed the hypothesis that the microbes could be fed the byproducts of the process of making biodiesel. JEA had conducted a Lean Six Sigma project in 2007 to address the problem of fats, oils, and grease (FOG) clogging water treatment machinery and solved it by sending the FOG to a local biodiesel processing facility, which created fuel to run the Jacksonville bus system. The biodiesel production process created methanol and glycerin as byproducts, which were exactly what the microbes required to thrive.

In the "Improve" and "Control" stages of the DMAGIC process, the project team implemented the following process changes:

- The utility worked with the City of Jacksonville to reclassify the waste products from the creation of biodiesel, which had been considered a hazardous waste material, as a product called Nitro-Gone.
- JEA now feeds Nitro-Gone to the microbes during the weekends, thus reducing nitrogen discharge to the river.
- In addition to normal processing through the tank farm, JEA introduced high temperature side stream processing. The utility created an improvement program to breed "super microbes" that were able to withstand the 106 degree Fahrenheit environment of the side stream, resulting in an even greater ability to reduce the nitrogen output into the St. Johns River.

Benefits from the St. Johns River Nitrogen Reduction Project:

- The utility reduced its nitrogen discharge to the St. Johns River by 74 tons per year.
- JEA was able to meet new federal standards for nitrogen discharges early, without investing in additional treatment technology and with reduced operational costs, through this effort.
- Customers have saved $6.57 per year due to avoided expenditures.
- The project provides JEA with a potential savings of $2.37 million per year from nitrogen credits.
- The project has increased cooperation between JEA and local municipalities by making room for the local municipalities to use some of the JEA nitrogen allowance. The municipalities use this allowance to meet their need to allow nitrogen from storm water runoff to enter the river.
- JEA developed a process to recycle a byproduct from biodiesel fuel production for a beneficial use and reduced the volume of materials that enter landfills every year.

- The project improved public perception of JEA and positively affected customer relations by recycling hazardous waste and reducing nitrogen discharge.

Improving Efficiency and Safety on Water Maintenance Trucks

Problem: Water Infrastructure Maintenance Truck Safety Issues and Reduced Productivity
In 2005, JEA conducted a Lean project on the Ford F-550 trucks based on Pearl Street that are used for water infrastructure maintenance in Jacksonville, Florida. The project sought to reduce safety incidents due to material layout on the trucks and to reduce the time it took for crews on the trucks to complete infrastructure maintenance jobs while using the trucks. The utility faced the problem of having had three recordable safety accidents and one first aid incident among crews working on the trucks in fiscal year 2005. The average time to complete a water maintenance job from May through September of 2005 was 78 minutes. The project's goal was to reduce the number of safety incidents that are caused by the layout of equipment on the trucks from two to less than one per quarter, while reducing the time that it takes to complete a maintenance job from 78 minutes to 65 minutes by March 1, 2006, without increasing Operations and Maintenance (O&M) costs.

Addressing the Problem with 5S
Within JEA's DMAGIC framework for Lean Six Sigma projects, the project team studied the process, using tools such as Pareto charts, X-Y matrix, direct process observations, root-cause analysis, and "five whys" questioning, and concluded that the top two factors leading to increased time were material being difficult to locate on the truck and material being difficult to get off of the truck. To address these concerns, the team used the Lean method of 5S to organize and standardize the materials on the trucks. 5S is a five-step process (Sort, Set in order, Shine, Standardize, and Sustain) designed to create and maintain a clean, neat, and orderly workplace. Through 5S, the team developed a standard system for configuring the bins and materials on trucks (allowing some regional variation in the quantities of materials), including labels and magnetic signs for bins and compartment doors, and notebooks with pictures and descriptions of each item. This standard system was implemented on all trucks used for water infrastructure maintenance.

Figure 3: Water Infrastructure Maintenance Trucks Before Lean Improvements

Figure 4: Water Infrastructure Maintenance Trucks After Lean Improvements

The team also created a plan to ensure that the new system would be sustained, which contained the following steps:

- A new committee, created as part of the Control phase of the DMAGIC analysis, is responsible for ensuring that all trucks implement best practices identically. New items can be added to the trucks only if the committee agrees.
- Trucks are inspected randomly by the manager.
- The Safety Health Awareness Promotion and Education (SHAPE) representative randomly checks the condition of trucks.
- Crew leaders assume responsibility for the condition of the truck.
- The condition of the trucks is included as part of the apprentice's daily performance responsibilities.
- Any concerns can be brought up in monthly safety meetings.
- If trucks are found to be in poor condition, the crew must make a safety presentation at the monthly safety meeting which is in front of over 100 people.

Benefits from the Water Maintenance Truck Safety and Efficiency Project:

- As of October 2010, there have been zero OSHA recordable accidents and no vehicle accidents since improvements were implemented in 2006.

- The average time to complete all types of tickets for Water Maintenance Crews was reduced from 78 minutes to 55 minutes.
- The average number of jobs per crew per day increased from 4.36 to 6.23.
- Based on the average of six crews working each day, the time savings from this Lean project allowed for approximately 479 more jobs per year.
- Reduced fuel costs by an estimated 10 percent per truck due to the lighter weight of the trucks.
- Improved customer satisfaction has resulted from jobs being completed in less time.
- Employees now work in a safer environment due to process improvements.

Process Improvements to Reduce Sanitary Sewer Overflows

In the past, sanitary sewer overflows have posed a significant problem at JEA, as there were 43 SSOs per month in 2002. JEA convened an SSO Reduction Initiatives Committee to address the problem, and a JEA Black Belt has been a member of that team since May 2004. Through a series of Six Sigma projects and initiatives guided by data-driven approaches, JEA has drastically reduced the number of SSOs occurring in its infrastructure. For example, a process improvement team observed that over 20 percent of SSOs occurred in ductile iron pipes, but that those pipes represented less than 2 percent of the linear footage of pipes in the system. The utility replaced most of those ductile iron pipes. In June 2010, there were zero SSOs, and only 30 SSOs occurred between October 2009 and September 2010.

Looking Toward the Future

The CEO of JEA has committed the utility to process improvement efforts, and in recent years JEA has won several international awards recognizing operational and process excellence. The aspiration toward success permeates the culture at JEA, and the utility's process improvement team of Lean Six Sigma "Black Belts" is dedicated to continuing its process improvement efforts into the future. The team will continue to review potential project opportunities four times per year, with input from JEA's CEO on the projects with the best potential. For example, in the fall of 2010, teams analyzed opportunities for improvement in the areas of water distribution and wastewater collection grids. JEA will strive to continue improving processes across the utility—reducing wastes, improving customer service, and saving money for the utility and its customers.